SEEDS Technology Infusion

Process and Plans
→ Including Workshop Participant Input

March 18-20, 2003

Third SEEDS Public Workshop

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Slide Sets

- **Plenary Session**
  - Summary of study findings & recommendations
- **Breakout Session 1: Process (3:30 Tuesday)**
  - Discussion of study findings & recommendations
  - SEEDS technology infusion process
  - Technology Infusion Working Group Straw Charter
- **Breakout Session 2: Plans (1:00 Wednesday)**
  - Prioritize Candidate Technology Infusion Initiatives
  - FY03 Activities, Milestones, Projects
  - Capability Vision

SEEDS Technology Infusion

Summary of Findings & Recommendations

Third SEEDS Public Workshop
Plenary Session

SEEDS Technology Infusion Study Overview

SEEDS FORMULATION

Purpose

- Define and conduct community-based processes to identify needed capabilities & technologies and infuse them into ESE data systems
  - Facilitate creation of a SEEDS capability vision
  - Define technology infusion initiatives
- Determine roles of ESTO AIST and SEEDS with regard to prototyping needs

Schedule

- 09/2002: Preliminary list of SEEDS capability needs
- 09/2002: Technology infusion process guidelines
- 10/2002: Study recommendations
- 12/2002: Technology infusion project proposals for REASoN CAN due
- 01/2003: Strawman SEEDS technology infusion plan
- 03/2003: Technology infusion planning session at SEEDS public workshop #3
- 09/2003: Capability vision definition session at SEEDS public workshop #4
- 09/2003: Assessment of initial infusion initiatives
- 09/2003: Draft SEEDS capability vision

Approach

- Engage the ESE community through workshops, working groups, and projects
  - SEEDS public workshops, AIST workshops
  - REASoN CAN working groups & projects
- Leverage current ESTO AIST processes
  - Evaluate the AIST strategic planning process relative to SEEDS needs
  - Get SEEDS representation at the annual ESE AIST Projections Workshop
  - Review AIST capability needs database in light of SEEDS concepts
  - Designate roles of ESTO AIST and SEEDS with regard to prototyping needs

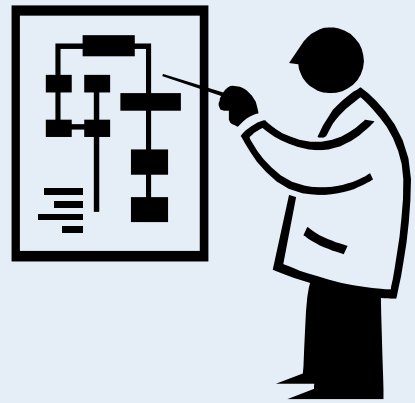
Status

- 11/2001: Identified preliminary list of SEEDS technology drivers
- 01/2002: Conducted AIST Projections Workshop
- 02/2002: Conducted technology infusion process session at SEEDS public workshop #1
- 05/2002: Conducted capability needs discussion at ESIP Federation meeting
- 06/2002: Conducted individual interviews with ESE community members to identify SEEDS capability needs
- 06/2002: Conducted capability needs definition session at SEEDS public workshop #2
- 10/2002: Provided formulation team study recommendations

#1: Improve Technology Infusion

- **Finding**
  - Many barriers impede technology exploitation
- **Recommendation**
  - Fund efforts to bridge the gap and overcome barriers

INFUSION
- Pilots
- Incentives
- Outreach



TECHNOLOGY DEVELOPMENT
- 15 Relevant Programs
- Web Services
- PC Clusters
- Etc.

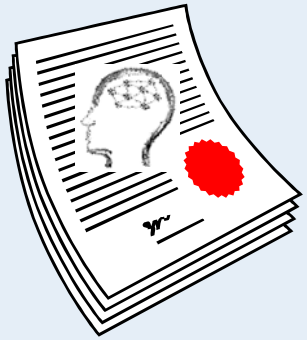
RESEARCH/APPLICATION NEEDS
- Data Fusion
- Near-Real-Time Delivery
- Subsetting & Tailoring
- Service Chains
- Seamless Search/Access

BARRIERS & PITFALLS
- Development/Operations Mismatch
- Inadequate Documentation
- Intellectual Property Issues
- Performance Risks
- Incompatible Infrastructures

#2: Define a Capability Vision

- **Finding**
  - Clearer objectives are needed to focus tech infusion efforts on the most critical capabilities
- **Recommendation**
  - Develop a SEEDS capability vision

NewDISS Concept Document



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Capability Themes

Required Features

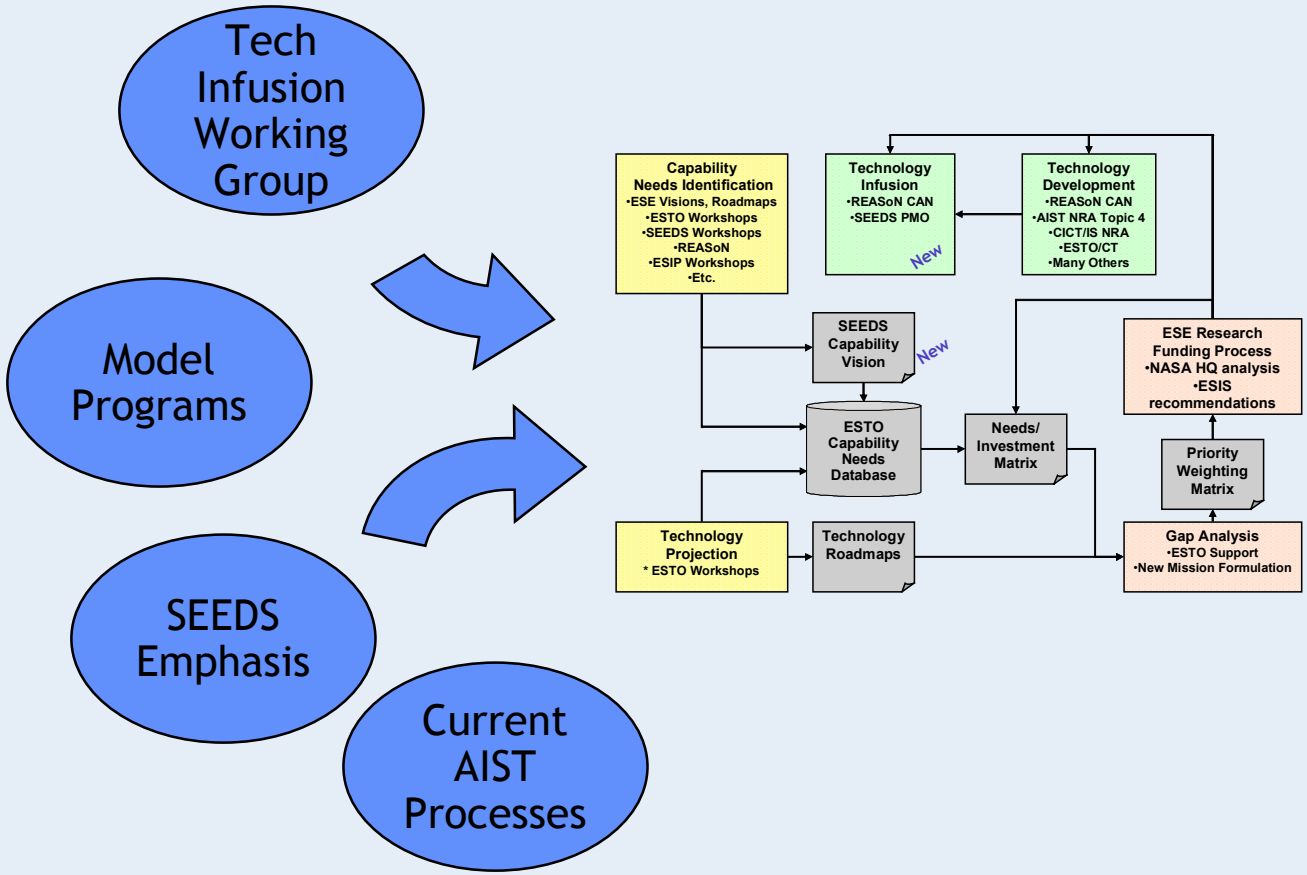
Quantitative Goals

Strategic Context

High-Level Implementation Plan

#3: Extend Strategic Technology Planning Processes

- **Finding**
  - AIST processes need to be extended for SEEDS to improve technology infusion
- **Recommendation**
  - Incorporate community-based technology infusion processes modeled on OGC Interoperability Program or DoD Advanced Concept Technology Demonstration Program



Workshop Sessions Today & Tomorrow

- **3:30 Tuesday: Process**
  - Discuss study findings & recommendations
  - Define SEEDS technology infusion process
  - Create Technology Infusion Working Group draft charter
- **1:00 Wednesday: Plans**
  - Prioritize candidate technology infusion initiatives
  - Define milestones
  - Start developing a capability vision

* SEEDS Technology Infusion

* Discussion of Findings & Recommendations
* Technology Infusion Process
* Working Group Charter

3:30 – 5:00 PM

Breakout Session 1
Third SEEDS Public Workshop

* SEEDS Technology Infusion

Discussion of Findings & Recommendations

15 min

Breakout Session 1
Third SEEDS Public Workshop

Open Discussion on Findings & Recommendations

- **Technology infusion effort is needed**
  - Key barriers are TRL 7-9 funding gap, license issues, performance risks, and incompatible infrastructures*
  - Solution is a combination of operational deployment projects, deployment incentives, education/outreach, and support/enablement
- **Capability vision is needed**
  - Contents include strategic context, capability themes, specific features/functions, quantitative goals, & implementation plan
  - Discussion of key capabilities deferred until breakout session #2
- **Technology infusion process**
  - Use AIST process as foundation
  - Incorporate community-based processes modeled on OGC Interoperability Program or DoD Advanced Concept Technology Demonstration Program

Does this generally reflect your past & current opinion?
Are the proposed solutions appropriate? Other suggestions?

*Source: SEEDS Public Workshops and one-on-one interviews

Open Discussion on Findings & Recommendations:
→ *Participant Comments*

- **Findings and recommendations are generally correct and appropriate**
- **Recommended model processes have both good and bad characteristics**
  - See later discussion on model processes for details
- **Tech infusion process needs to consider both "technology push" and "requirements pull"**
- **Tech infusion process should focus on off-setting the risk of first use**
- **Technology infusion needs to consider the technology lifecycle**
  - Needs identification, tech development, gap analysis, tech infusion, repeat
  - ESE goals and SEEDS vision drive needs identification
- **Need to focus on the role of people in the infusion process**
- **Tech infusion needs to consider operational agreements**
  - A technology that works does not necessarily work well
- **Need to show relationship to reuse effort**
  - Tech infusion should focus on new technologies that offer significant capability increases and which have significant risk associated w/ adoption
  - Reuse should focus on cost savings from reuse of operationally-proven components
- **Need to define who is responsible for developing the capability vision**
- **Need to define "technology"**
- **Should focus on incorporation of underutilized technologies instead...attempts to envision the future are difficult**

* SEEDS Technology Infusion

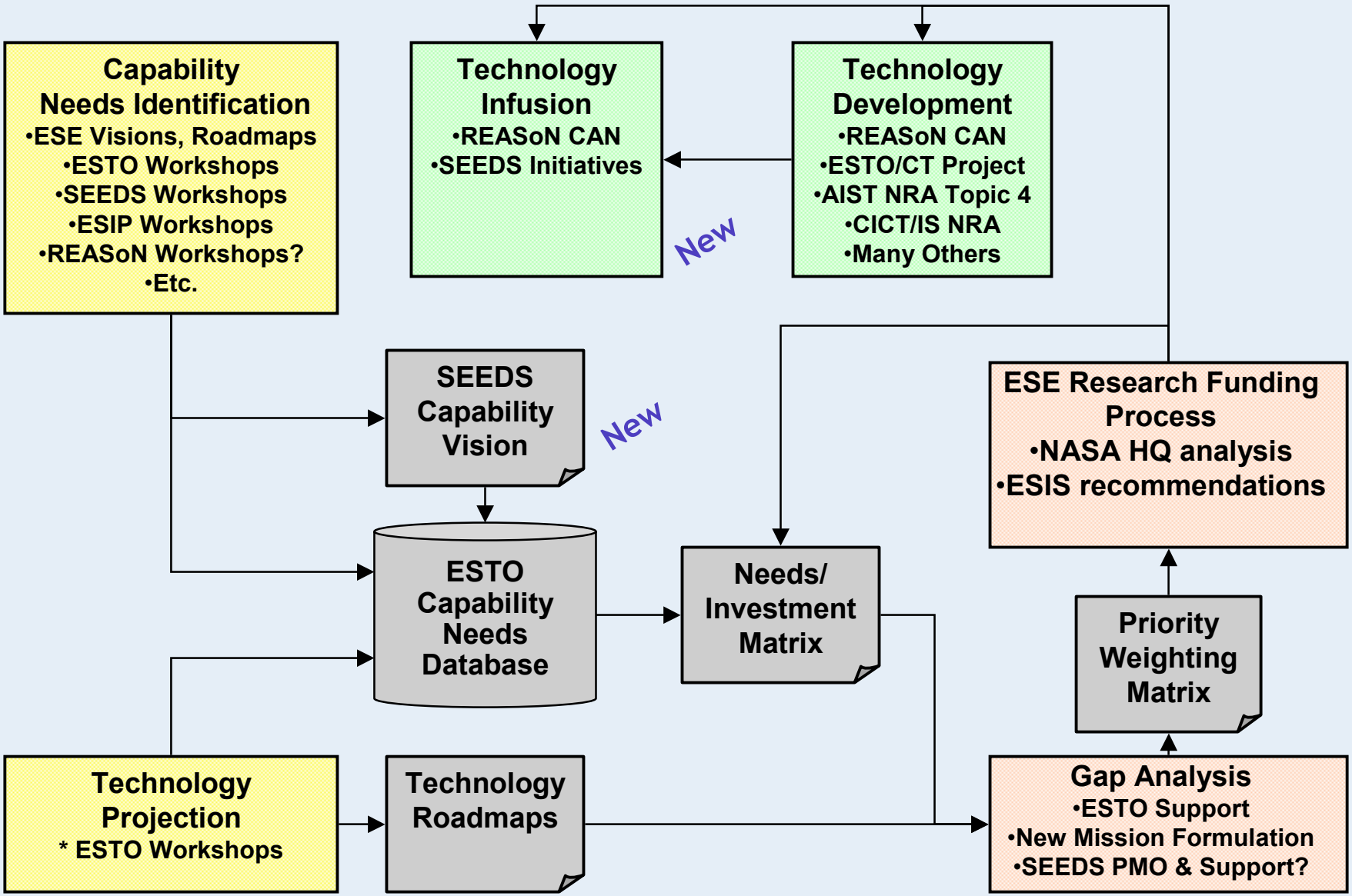
Definition of a Technology Infusion Process

50 min

Breakout Session 1
Third SEEDS Public Workshop

SEEDS Technology Infusion Process: Overview

- Utilizes & extends current AIST processes for SEEDS



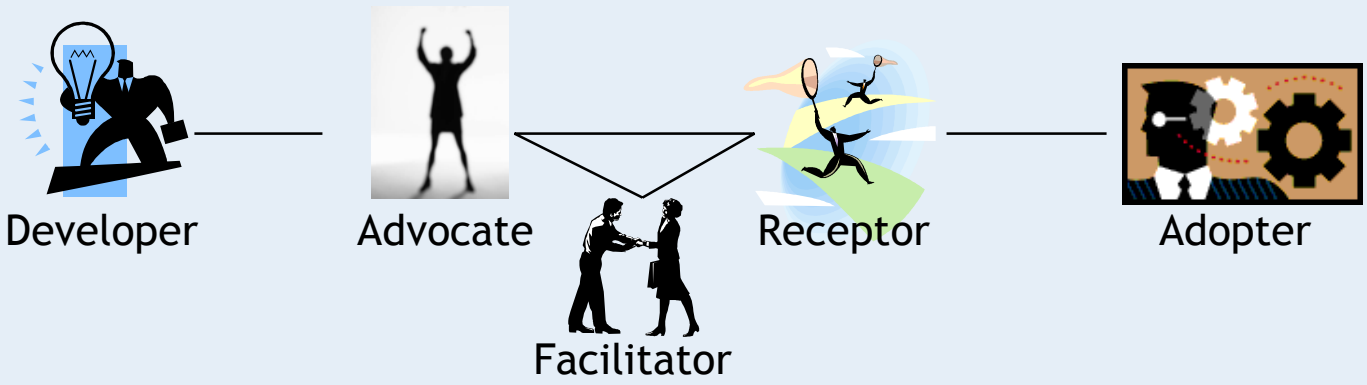
Process Overview Discussion
{Topic not covered in workshop due to time constraints}

- What technology infusion activities does your organization sponsor or participate in? Who funds them?

- Are there other places in the process where community involvement is needed?

SEEDS Technology Infusion Process: General Roles & Responsibilities {Topic not covered in workshop due to time constraints}

- **Developer**
  - Producer of new technology
  - Interprets capability vision and develops relevant technologies
- **Advocate**
  - Understands potential of new technology and seeks out users/applications
- **Receptor**
  - Understands capability needs and seeks out relevant technologies
- **Adopter**
  - Consumer of new technology
  - Makes risk/reward trade-offs in technology adoption decisions
- **Facilitator**
  - Provides different forums for advocates and receptors to exchange information

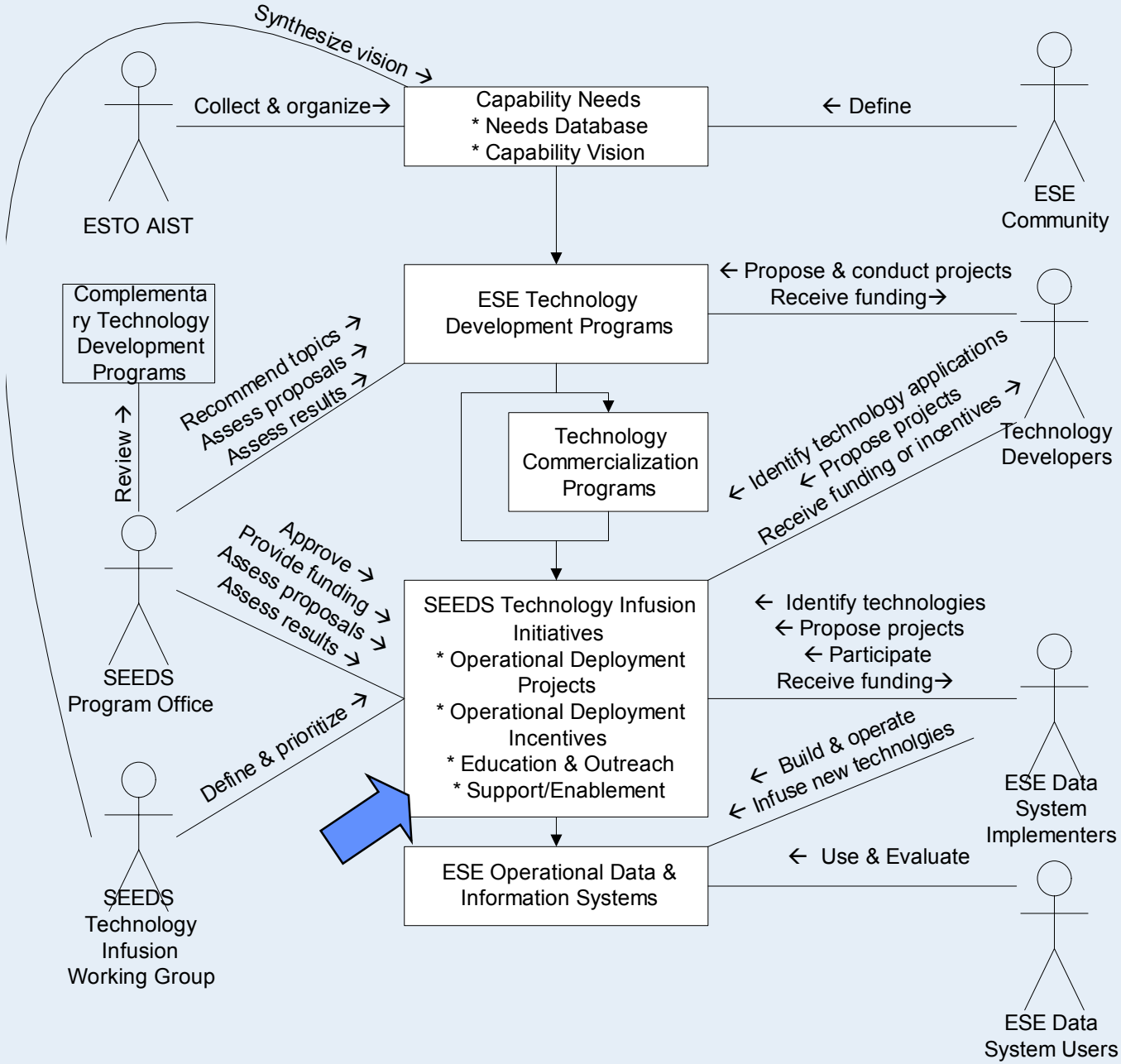


Source: Fowler & Levine (except facilitator)

General Roles & Responsibilities Discussion
{Topic not covered in workshop due to time constraints}

- **What is your role in the technology infusion process?**
- **Developers:**
  - Who is your advocate?
  - How important is marketing, and is this a valid activity to support with technology infusion funds?
  - Have you successfully deployed an ESE-specific technology outside your organization? How?
- **Advocates:**
  - Are there any in the ESE data system community who are not also developers?
- **Receptors:**
  - How do you find technologies that are not actively marketed?
  - Do you know what technology development ESE is currently funding?
- **Adopters:**
  - How do you influence technology development priorities? Could this process be improved?
  - Have you successfully adopted a new ESE-specific technology from outside your organization? How?

SEEDS Technology Infusion Process: Specific Roles & Responsibilities



Specific Roles & Responsibilities Discussion
{Topic not covered in workshop due to time constraints}

- **What kinds of technology infusion initiatives are the most important**
  - Deployment projects?
  - Incentives?
  - Education & outreach (incl. facilitation/matchmaking)
  - Support & enablement (incl. policy/licensing)

Candidate Technology Infusion Strategies- General {Topic not covered in workshop due to time constraints}

- **People Mover**
  - Relies on personal contact between developer and user
  - Prevalent and effective method
- **Communication**
  - Relies on information dissemination and information search/browsing to connect developer and user
  - Web catalogs and matchmaking Web sites serve this purpose
- **Packaging**
  - Requires technology to be packaged so it can be picked up by non-experts
  - COTS software emphasizes this method
- **Vendors**
  - Relies on vendors to identify and sell to potential technology users
  - COTS software emphasizes this method
- **Policy**
  - Uses policy to drive technology adoption (e.g., mandated standards)

Source: Berniker E., Models of technology transfer (A dialectical case study), IEEE Conference: The New International Language, Portland, OR, (July, 1991), 499-502.

General Infusion Strategies Discussion
{Topic not covered in workshop due to time constraints}

- **Which strategies should ESE emphasize?**
  - People mover?
  - Communication?
  - Packaging?
  - Vendors?
  - Policy?
- **How can technical solutions based on emerging, free, and open source software compensate for the lack of vendors?**

Candidate Technology Infusion Strategies- Specific

- **Suggestions**
  - Extend technology development funding past TRL 7
  - Fund travel of developers to user sites
  - Promote licenses and release procedures that facilitate technology exchange

Candidate Technology Infusion Strategies- Specific:
→ *Participant Comments*

- Technical mechanisms: Provide a component architecture & extension interfaces to service providers that allows new capabilities/technologies/services to be plugged in to the system (e.g., ECHO)
- Process & Methodology: Ensure surveys of available technology are included in every development process
- "Magnet" or marketing approach: Draw new services to a common gateway, and possibly rate or endorse services
- Operations "pull" approach: Leverage user working groups and science teams at DAACs
- Policy approach: require technology developers to partner with user or get endorsement from data provider (a la CICT NRAs)
- "Harden" prototypes through GGF or similar venues
- Timing: provide information and guidance at key points in the project lifecycle
- Targeted: provide needed information to decision makers
- Certification approach: test & validate new components through the Open Group or a T&V contractor
- Policy approach: avoid unintended disincentives in grant/contract funding; for example, why would someone deploy a technology developed by someone else if they can get more money & ownership by building it from scratch?
- Indirect matchmaking: leverage system integrators looking to match users with technology
- Policy approach: provide incentives to save costs by employing newly developed technologies
- Tailored: use different strategies for different technology scope (wide or narrow use, infrastructure or application impact)
- Funding approach: directly fund deployment of new technology, documentation, quality assurance, support/help desk; alternatively, provide funding incentives
- Establish ".org" to adopt / support a technology or host a user group (a la UCAR, ESIP Fed "Foundation")
- Grant/contract approach: encourage or require products to be open source so anyone can use them (DOE & NSF?)
- Grant approach: require technology development proposals to be sponsored by an end-user organization (a la Applications Division)
- Outreach & education: support workshops on the use of new technologies (e.g., GGF, FGDC)
- Marketing: Service publishing & promotion, e.g., through ECHO
- Metrics approach: Establish requirements & metrics to motivate projects to incorporate new technologies
- Modularity: Keep interfaces & technology elements small & digestible (not like Ipv4 to v6)

Model Processes

- **Open GIS Consortium (OGC) Interoperability Program**
  - Designed to deliver proven candidate specifications to the OGC Specification Development Program or to exercise/promote existing specifications
  - Consists of testbeds, pilot projects, and technology insertion projects
  - 14 projects (9 complete)
  - Details at http://ip.opengis.org/
- **DOD Advanced Concept Technology Demonstrations**
  - Designed help expedite the transition of maturing technologies from developers to users, esp. adapting concept of operations to new techologies
  - Consists of end-to-end operational demonstrations in real military exercises at a scale sufficient to assess utility; 84 ACTDs conducted in 1995-2001 timeframe (32 complete)
  - Fully documented formulation, selection, and initiation process
  - Details at http://www.acq.osd.mil/asc/
- **Software Engineering Institute (SEI) Technology Transition Practices**
  - Goal is to identify, develop, promote, and apply practices that result in more rapid, affordable, and sustained transition of innovative software engineering technologies
  - Details at http://www.sei.cmu.edu/ttp/
- **NSF Software Capitalization Program**
  - Funded distribution/sharing of research related software (e.g., HDF libraries)

Model Processes Discussion

- **What other processes could serve as a model for a SEEDS technology infusion initiative?**
- **Which approach do you like best? {Topic not covered in workshop}**
  - Pilot projects focused on standards (OGC IP)?
  - End-to-end multi-participant demonstrations focused on evaluation (DoD ACTD)?
  - Process engineering/management (SEI TTP)?
  - Funded deployment & support of specific software assets (NSF SCP)?
- **What should be the output of a technology infusion project? {Topic not covered in workshop}**
  - Knowledge & experience
  - Acquisitions
  - Standards
  - Deployed technology

Model Processes Discussion:
→ *Participant Comments*

- **Some caution with respect to the recommended process models...there are good and bad aspects of each**
  - ACTDs
    - Good: multi-organizational participation results in cross-fertilization of ideas; fully funded efforts
    - Bad: selection process sometimes results in competitive vs. cooperative atmosphere; might be expensive
  - OGC
    - Good: emphasizes exploration of what new capabilities can be provided by a technology
    - Bad: partially funded or self-funded activities reduces participation
- **Other candidate model processes**
  - SBIR
  - NSF

* SEEDS Technology Infusion

Technology Infusion Working Group Charter

15 min

Breakout Session 1
Third SEEDS Public Workshop

Technology Infusion Working Group Draft Charter

- **Goals**
  - Help the working group get started quickly & productively
  - Capture general direction and key points
- **Excluded Goals: we are not...**
  - Crafting final text
  - Defining a comprehensive task list
  - Carving the working group agenda in stone

Technology Infusion Working Group Draft Charter

SEEDS FOCUS AREA

- **Mission?**
  - Enable NASA's ESE to reach its research and application goals more quickly and cost effectively through widespread adoption of key emerging technologies for information systems
- **Goals & Objectives?**
  - Establish and carry out a technology infusion process in support of SEEDS and the ESE science and application goals
  - Create a capability vision for Earth science information systems in the SEEDS era, identify technologies that are critical to achieving that vision, and facilitate infusion of critical technologies into operational ESE information systems
- **Initial Tasks & Deliverables?**
  - Establish a detailed work plan consistent with the goals and objectives of the working group (start + 1 month)
  - Review, refine, and recommend changes to the baseline technology infusion process (s+2)
  - Develop a list of recommended technology infusion initiatives with estimated costs & benefits of each (s+4)
- **Expected Outcomes & Performance Metrics?**
  - Wider use of key technologies (% utilization of key enabling technologies)
  - Faster adoption of key technologies (Key technology adoption rate in % per month)
  - Broader recognition of key capabilities & technologies (Dissemination of list to stakeholders)

Is this headed in the right direction?

Volunteers for more detailed discussion via telecon?

Technology Infusion Working Group Draft Charter (cont'd)

- **Membership?**
  - Members: REASON CAN awardees, SEEDS PMO, ESTO
  - Membership criteria: ?
  - Chair: elected by the working group
- **Scope?**
  - Information technologies critical to the SEEDS vision that have been fully developed, but that have not been widely deployed and may be slow to be adopted because of the unique characteristics of Earth science
- **Authority?**
  - Chartered by the SEEDS PMO with participation funded by the REASON CAN
  - Authorized to recommend technology infusion initiatives to the SEEDS PMO

Is this headed in the right direction?
Volunteers for more detailed discussion via telecon?

Technology Infusion Working Group Draft Charter:
→ *Participant Comments*

- **Mission**
  - Enable infusion of technologies into ESE systems in such a way as to ensure measurable, highly-innovative, cost-effective technology evolution
- **Goals & objectives**
  - Reduce / mitigate risks when adopting new technologies
  - Enrich the suite of technology available to meet ESE goals
- **Approach (addendum to mission)**
  - Facilitating communicating between providers & consumers
  - Facilitating policy adherence
  - Identifying & defining technology infusion processes
  - Establishing incentives
  - Establishing metrics
  - Defining technology needs & gaps
  - Mapping Tech infusion strategies to ESE vision & strategies
- **Initial tasks & deliverables**
  - Identify/assess ESTO-developed technologies for infusion
  - Define draft policies & strategies for maturing technologies
  - Assess work involved in moving from TRL7 to TRL9 to identify problems, best practices
  - Identify capability gaps
  - Perform matchmaking between tech providers and SEEDS DSPs (current and those planning the next new mission)
  - Publish/ promulgate success – education, best practices, knowledge sharing, synergy/discovery
  - Capture & consolidate data service provider requirements
- **Expected outcomes & performance metrics**
  - Define use, value of tech infusion experiment
  - First use should document lessons learned
  - Need a mechanism to measure increased capability
- **Miscellaneous**
  - Lessons learned through deployment failures are valuable too
  - Maturation phase has overlap between tech infusion and reuse
    - Tech infusion should focus on new capability/ advance; working group should focus on the first credible use of a technology
    - Reuse should focus on cost reduction

SEEDS Formulation

* SEEDS Technology Infusion

* Near Term Capability Needs
* Capability Vision

1:00 – 2:30 PM

Breakout Session 2
Third SEEDS Public Workshop

SEEDS Capability Needs Discussion

- **Goals**
  - Begin defining a capability vision for ESE data systems
  - Capture general direction and key points
- **Excluded Goals: we are not...**
  - Establishing immediate funding priorities
  - Changing the NRA or CAN processes

SEEDS Formulation

* SEEDS Technology Infusion

Near Term Capability Needs

30 min

Breakout Session 2
Third SEEDS Public Workshop

SEEDS Capability Needs Discussion

- **Review the list for completeness**
  - Does the list correctly reflect prior community input and current opinion?
  - Have we really identified everything we need tomorrow that we don't have today?
- **Prioritize the capabilities**
  - A: high priority, must have
  - B: medium priority, should have
  - C: low priority, nice addition

SEEDS Capability Needs Discussion

- **Collection**
  - Data models to handle emerging data collection methods (nano-technology, non-gridded data)
- **Ingest**
  - None identified
- **Production**
  - Mechanisms to show data lineage to trusted data sources and transformations applied along the way
  - Automated/assisted data QA to provide fast, complete assessments
- **Storage**
  - Low cost processor-storage interconnect for computing clusters
  - File compression supporting block decompression for efficient subsetting on retrieval
- **Search & Order**
  - Content-based search mechanisms to reduce dependency on manually-created metadata
  - Expert search assistant a la AskJeeves or Amazon perhaps facilitated by semantic webs or domain semantics
  - Seamless catalog-to-data access
- **Distribution**
  - Web self-throttling capabilities to handle a broader user population with more data processing capability (HW & SW)
  - Tailored information not pre-packaged data (format, range, parameters, processing)

Source: SEEDS Public Workshops #1 & #2

SEEDS Capability Needs Discussion (cont'd)

- **Analysis/Exploitation**
  - Easier data fusion to enable more complex models, more interdisciplinary science, and diverse applications
  - Flexible toolkits that can adapt to changing user needs
  - Better support (e.g., plug-ins) for commercial application packages like ArcInfo, IDL
  - Tools to enable chains of value-added services (e.g., aggregation servers) to fulfill application needs
  - Tools to improve handling of missing data
  - High-level data manipulation language that enables building new products from multiple sources
- **General & End-to-End**
  - Near-real-time data delivery to support apps related to weather, disaster relief, etc.
  - Automated operations optimization to enable real-time data delivery, lower costs, and increased up-time
  - Transparent security mechanisms

Source: SEEDS Public Workshops #1 & #2

SEEDS Capability Needs Discussion:
→ *Participant Comments*

- **Additional capability needs**
  - Seamless catalog-to-data access
    - Including automated (machine-to-machine) access, not just human-driven
  - Global data & services access
    - Single-sign-on distributed systems infrastructure
    - Universal data/service registry
    - Integrated billing/accounting
  - Data lineage
    - Including authenticity watermarks (analogous to licensed music)
  - Personalization
  - Ability to move computation to data (production)
  - Autonomous system management and other Intelligent Archives concepts
- **Other comments**
  - Capability vision depends on the business model or concept of operations for SEEDS
  - Capability needs should be validated w/ end users not represented at this workshop
  - Capability vision should be split into science and system perspectives
  - Need to look at Intelligent Archives paper for a consolidation of additional ideas
  - Capability vision should recognize that needs vary by community
  - Capability vision should look beyond today's problems

Source: SEEDS Public Workshops #1 & #2

* SEEDS Technology Infusion

Candidate Tech Infusion Initiatives & Activities

{This section was not covered in the workshop due to extended discussion on capability needs}

50 min

Breakout Session 2
Third SEEDS Public Workshop

Industry Trends Discussion:
Rate these statements as "true" or "false"

- **Current state**
  - Data access is still too slow
    - Must retrieve big chunks rather than only what is needed
    - Communications bandwidth is a limiting factor
    - First-in, first-out processing does not always meet the demand of near-real-time applications
  - Data is still too hard to use
    - Disparate data models across different communities
    - Cryptic and undocumented formats still used
  - Awkward security implementations are increasingly an impediment
    - Simplistic one-size-fits-all policies are too restrictive
  - Processing and storage price/performance is adequate
    - Inexpensive computing clusters and RAID arrays perform well
  - Systems are too hard to use or missing capabilities
    - Support for new mission data formats takes too long
    - Systems are more and more complex, COTS products have problems/conflicts
    - Generalized solutions don't meet special needs, specialized solutions don't meet general needs
- **Industry trends**
  - Commercially-motivated improvements in basic processing, storage, and communications will meet most SEEDS needs
  - Commercially-motivated improvements in higher-level services (e.g., Web services) will be very useful but will not be focused on the specific needs of science data handling

10 Source: SEEDS Public Workshops #1 & #2 + individual interviews

Gap Analysis: Opportunities & Threats (optional)

SEEDS Foundation

- **Opportunities**
  - Pervasive XML → ESE Web services
  - Inexpensive communications & persistent storage → on-line data pools
  - Data and computing grids → distributed storage & compute servers
  - Low-cost computing clusters → cluster storage systems, cluster support services
  - Open source software infrastructure → community-driven development processes
  - Natural language processing & speech recognition → improved search/order interfaces
  - Robust electronic commerce → on-line order payment
  - Robust COTS geospatial application frameworks → reusable algorithm plug-ins
  - Other?
- **Threats**
  - High-cost people + low cost hardware → system development/operations automation
  - Increasing security concerns → electronic authentication infrastructure
  - Increasing system complexity → intelligent/assisted search, system operations
  - Other?

Does this list capture the most important opportunities & threats?

5 Source: SEEDS Technology Infusion Study interviews & assessments; Gartner Group

Candidate Initiatives

- Web services infrastructure?
- Low-cost computing clusters?
- Value-added service chains?
- Others?

What technology infusion initiatives ("technical topics") are needed to cover/satisfy the identified capability needs?

Note: The full set of initiatives will be defined by the SEEDS Technology Infusion Working Group.

Example Initiative Definition: Web Services Infrastructure

- **Problem**
  - Service encapsulation is an attractive approach to software reuse, but critical mass has not been reached on enabling standards and technologies
  - Investigator-led processing could benefit from Web services approach, but some common elements of the infrastructure are needed
- **Objective**
  - Operationally deploy critical components of a Web service infrastructure that enables an operational science computing facility to more fully participate as an ESE data provider
- **Strategies**
  - Deploy service directory and other common infrastructure components
  - Encapsulate one service as an example and document the process and lessons learned
  - Conduct a Web services tutorial at a SEEDS workshop

Candidate Activities

- **Deployment Projects**
  - CANs
  - Coordinate large-scale operational demonstrations?
  - ?
- **Education & Outreach**
  - Sponsor conferences on various capability topics?
  - Sponsor workshops on successful technology adoption/infusion?
  - ?
- **Support & Enablement**
  - Conduct workshops to refine the SEEDS capability vision?
  - Create/disseminate license templates that reduce technology adoption risks?
  - ?
- **Deployment Incentives**
  - ?

What activities should be part of each technology infusion initiative?

Background

Definitions

SEEDS FORMULATION

- **Technology Infusion**
  - The gradual process of identifying, understanding, adapting, and incorporating new but fully developed technologies into a set of systems
  - Distinct from, and complementary to, technology research and development
    - Primarily concerned with utilizing a technology, not creating it
- **Capability Vision**
  - A high-level, user-oriented description of the key future capabilities of ESE data systems
  - Intended to highlight the functional improvements that must be made to reach the science and application goals of the ESE
  - Provides guidance for technology development and infusion efforts
  - Distinct from a technology vision
    - Defines what capabilities are needed, not how they are provided

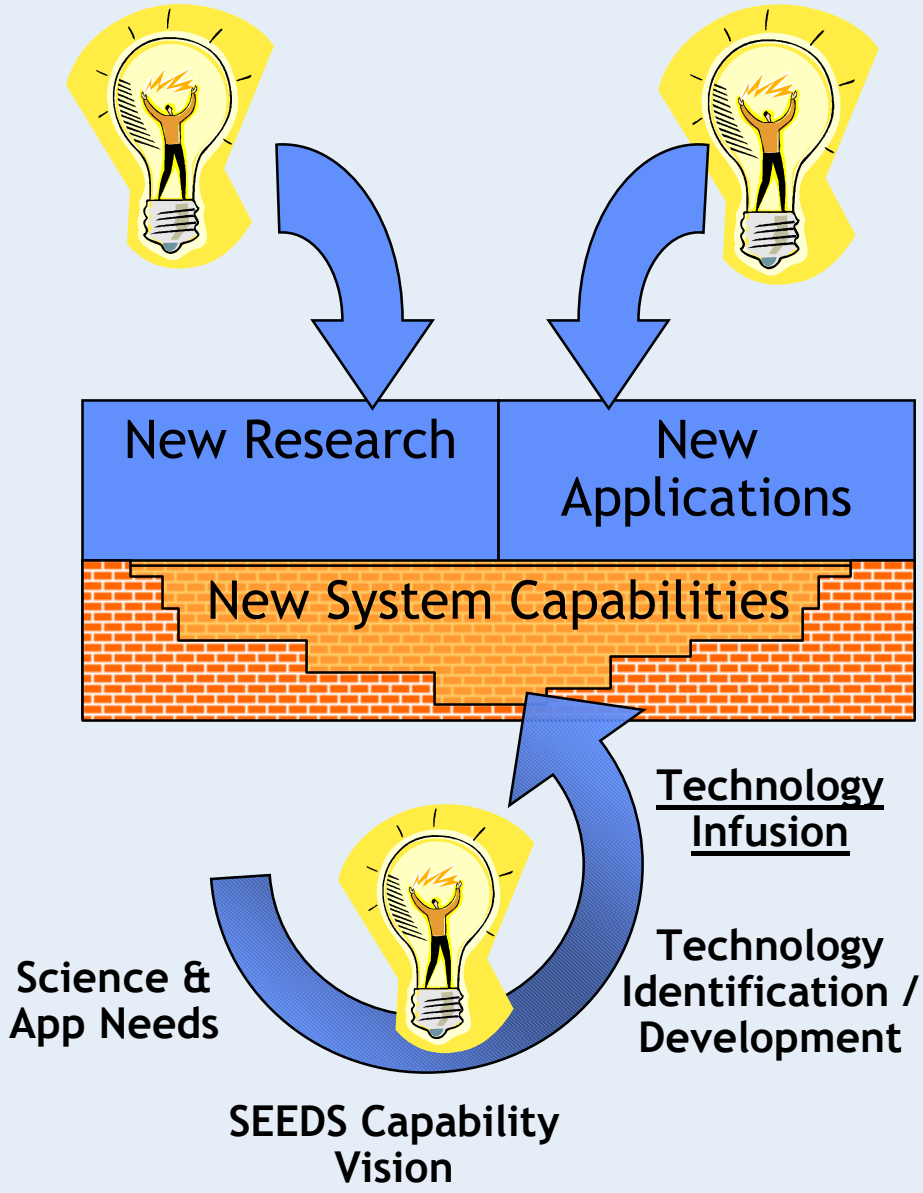
Source of Recommendations

SEEDS Formulation

- **Community Input**
  - SEEDS Public Workshop #2 (35+ active participants)
  - Individual interviews (6+)
  - SEEDS Public Workshop #1
  - ESIP Federation SEEDS Cluster
- **Identified many important elements of (inputs to) a SEEDS vision**
  - 49+ capabilities
  - 12+ specific features
  - 18+ current barriers to reaching ESE goals
  - 26+ prototypes of relevant technologies
  - 32+ technology/science/application trends
  - 5 barriers to technology infusion
  - 2 recommendations on vision representation
- **Light summarization of input**

Motivation: Meeting ESE Goals Requires Tech Infusion

- **Science and applications challenges = information system challenges**
  - Increased accuracy/precision in physical models
  - Increased demand for near-real-time data
  - Increasing need to combine different data sources
  - Continually increasing data volumes
- **ESE strategic priorities depend on infusing enabling technologies**
  - Open distributed architecture for PI processing
  - Earth science extension network for state & local information exchange
- **Technological opportunities abound but need to be exploited**
  - Significant improvements in Web and grid computing technologies
  - New computing architectures using commodity hardware
  - Results from NASA technology development investments



* Goals extracted from "Exploring Our Home Planet: Earth Science Enterprise Strategic Plan"

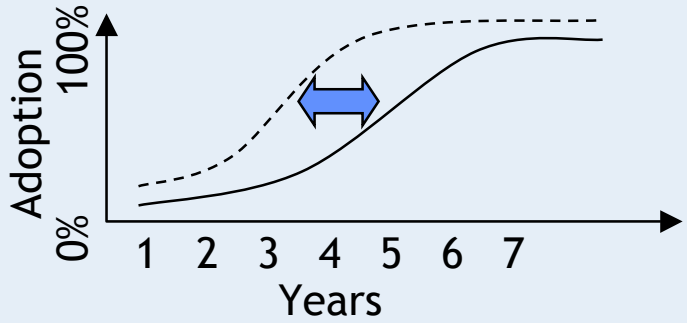
Motivation: Technology Infusion is Central to SEEDS

SEEDS FOLLOW-ON

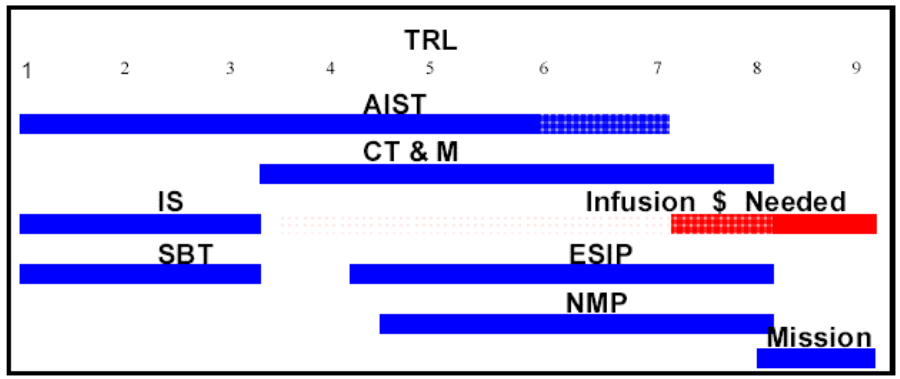
- **Poor technology infusion was an original "NewDISS" driver**
  - Systems were not keeping pace with technology advances
- **SEEDS concepts inherently promote technology infusion**
  - PI processing brings knowledge of needs and responsibility for change closer together
  - Peer review and competition should encourage innovation
  - Adoption of interface standards is itself one aspect of technology infusion
- **Results of SEEDS PMO activities should make technology infusion easier**
  - Standards and interfaces should further facilitate technology adoption
  - Governance solution may provide a forum for technology adoption
  - Metrics and cost modeling could make the benefits of technology infusion measurable
- **SEEDS concepts also create challenges to technology infusion**
  - Technology developers must market to an even more dispersed set of technology users
  - Technology adoption decisions must be made by dozens (hundreds?) of data providers *for the same technology*
  - Smaller providers have smaller operational bases over which to amortize infusion efforts
  - Innovative technologies may not work with broadly adopted standards…what then?
- **A thoughtful technology infusion effort for cross-cutting technologies could enhance SEEDS**
  - Faster adoption of critical technologies
  - Less duplication of effort
  - Does not interfere with individual technology adoption decisions

Motivation: A Technology Infusion Effort is Needed

- **Time is valuable**
  - Technology adoption is typically a slow process (e.g., 7 years from development to widespread adoption*)
  - Common practice lags the state-of-the-art significantly
  - Slow adoption of critical technologies means lost opportunities, higher costs, unhappy users



- **ESE has unique needs**
  - Fully-developed technologies can be risky under the load of large geospatial data sets
  - This is not about shrink-wrap software!
- **Current programs leave a gap**
  - Technology development ends at TRL 6/7
  - Operationally deployable at TRL 9
  - Potential for "orphaned" technologies
- **Technology infusion is relatively neglected**
  - 15 relevant information technology <u>development</u> programs identified
  - 0 relevant information technology <u>infusion</u> programs identified



Infuse It or Lose It

* Source: Redwine S. and W. Riddle, Software technology maturation, 8th IEEE/ACM International Conference on Software Engineering, London, UK, August, 1985, 189-200. See also Zelkowitz M. , "Software Engineering Technology Infusion within NASA." IEEE Transactions on Engineering Management., Aug 1996.

Why Technology Infusion within SEEDS PMO?

SEEDS FORMULATION

- **Right place to fill the gaps**
  - ESTO will develop technology
  - Projects will deploy proven technology
  - SEEDS should facilitate making newly developed technologies deployable
    - Incentives, enablement, outreach/education, adaptation to "grease the skids"
    - Focus on early adopters to create momentum
    - Accelerate adaptation and adoption of technologies critical to the SEEDS vision
- **Cross-Project Perspective and Leverage**
  - The SEEDS PMO is uniquely positioned to identify and address cross-cutting needs
    - Coordinated infusion across projects and providers could yield significant time and cost savings
  - Individual projects and data providers necessarily have a more limited focus
    - Local optimizations will not yield a global optimum
  - Agency and enterprise technology necessarily have other interests
    - Technology development or flight emphasis vs. technology infusion and data system emphasis
    - Driving concept behind New Millennium Program needs to be applied on a smaller scale to ESE data systems
- **Vested Interest: Enabling the SEEDS Vision**
  - Capabilities envisioned under SEEDS to meet ESE goals require not only innovative program approaches but also use of innovative technologies
    - Web services and other emerging technologies are essential but not yet broadly deployed
  - SEEDS standards and interfaces must be defined and implemented
    - Infusing supporting technology into systems is required for follow-through

Global IT Trends

- **External forces**
  - IT industry consolidation
  - Emphasis on security, privacy, safety
    - Passport, Liberty, TCPA, Palladium
  - Consumers going on-line
- **Business behavior**
  - Continuing budget constraints
  - Reliance on outsourcing and trusted suppliers
  - Emphasis on CRM
- **Application trends**
  - Continuing reliance on IT
  - Obsolescence of mobile applications
  - Domination of Web services for new applications
    - J2EE, .NET
  - Emphasis on application integration
  - Network capacity increasing faster than processing or storage
    - Enables remote services, grid computing, remote collaboration

Source: Gartner Group 2002

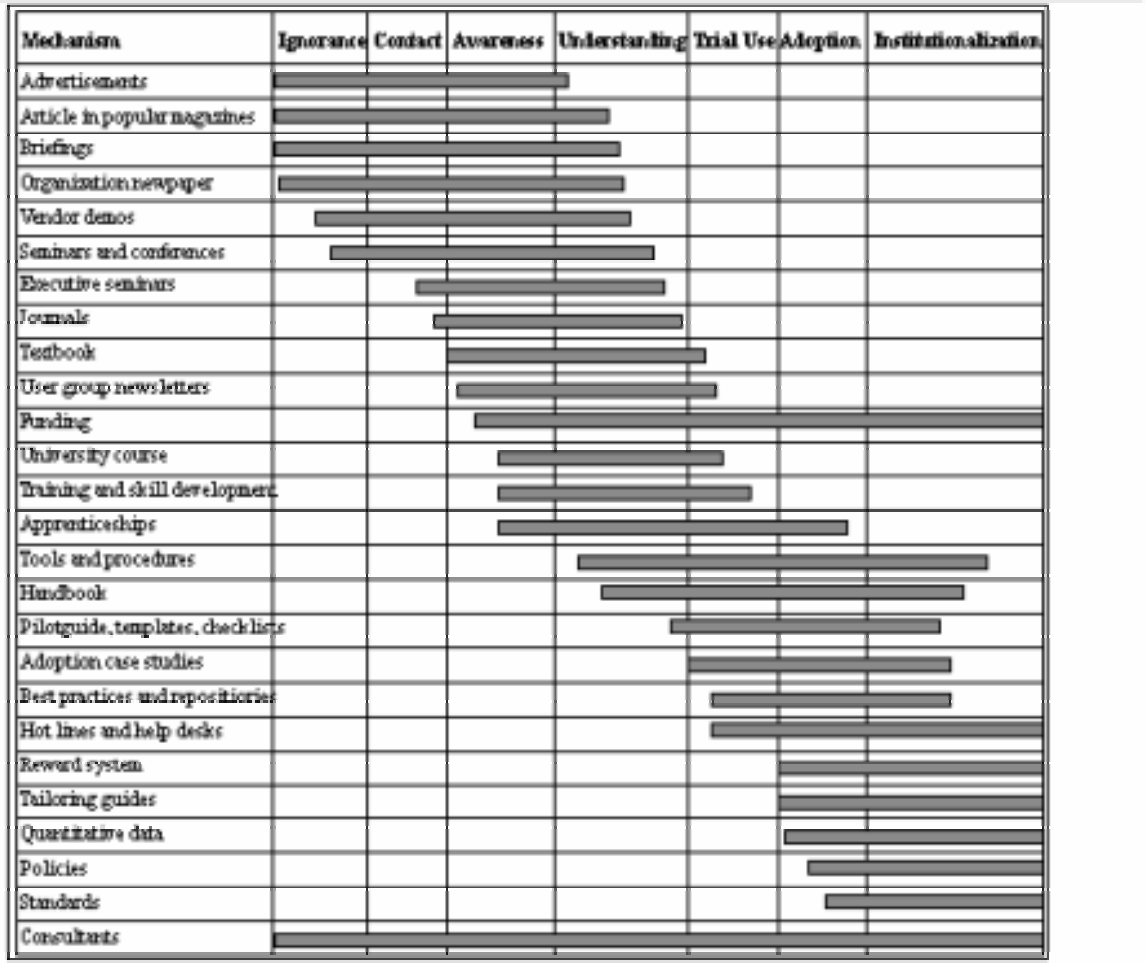
Global IT Trends (cont'd)

- **Key technologies**
  - Digital subscriber lines
  - Low-cost computing and communications hardware
  - Natural language information retrieval
  - Extranets
  - Speech recognition
  - Internet telephony & internet chat
  - Biometrics
  - Electronic books
  - Wearable computers
  - Avatars

Source: Gartner Group

Technology Transition Mechanisms

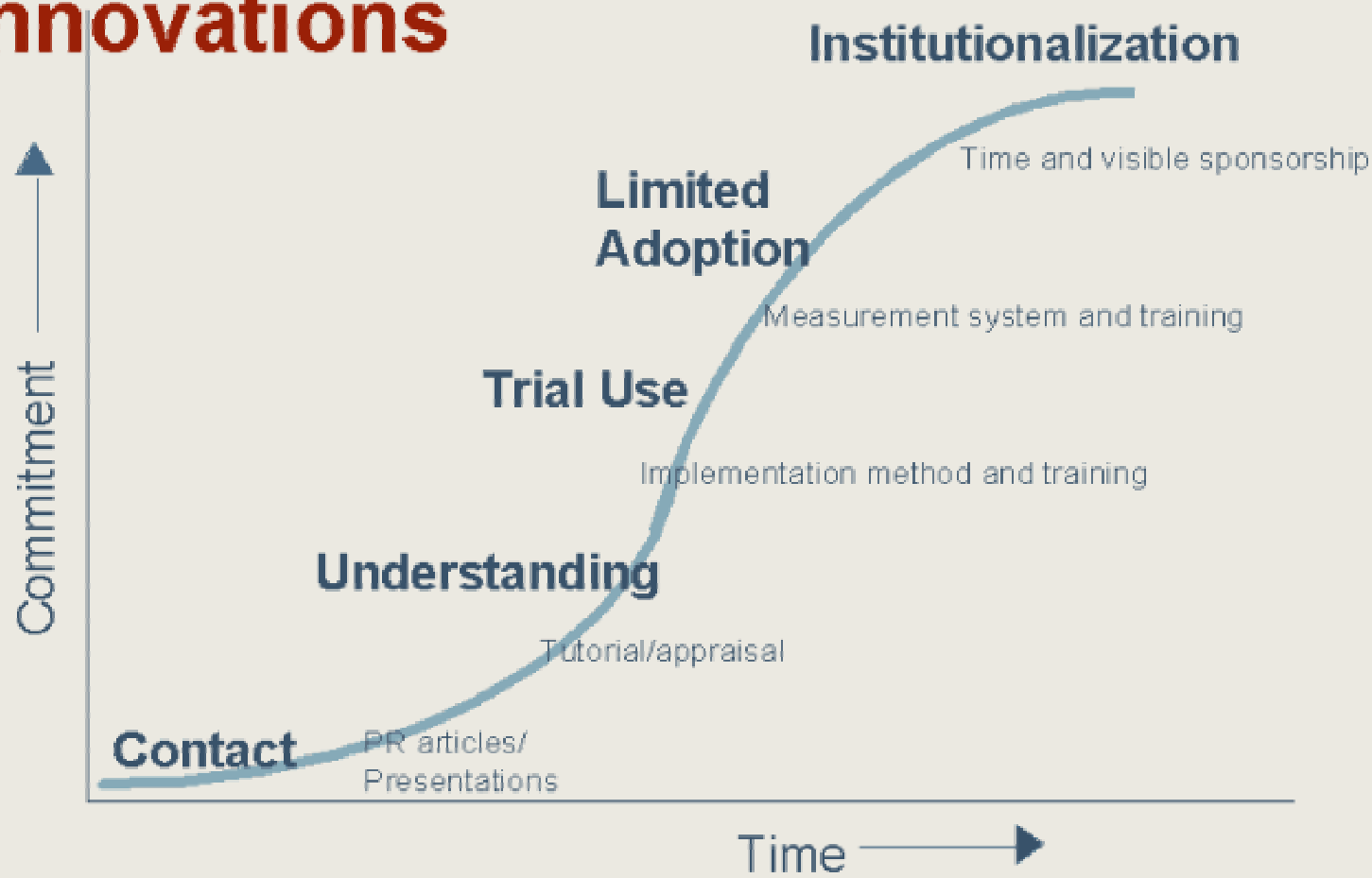
Carnegie Mellon University
Software Engineering Institute



 Version 1.0 Technology Change Management - page 19

 Version 1.0 page 6

How people commit to innovations



* Daryl R. Conner and Robert W. Patterson. "Building Commitment to Organizational Change," *Training and Development Journal* (April 1983):18-30.

 Version 1.0 page 2

References

- Everett Rogers, *Diffusion of Innovations*
- *Malcolm Gladwell, The Tipping Point: How Little Things Can Make a Big Difference*
- Tor Larsen and Eugene McGuire, *Information Systems Innovation and Diffusion: Issues and Directions*
- Eric A. Von Hippel, *The Sources of Innovation*